
FUNGAL DISEASES OF COCONUT IN THE WORLD

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ABSTRACT

A wide array of fungi attack coconut palm causing different degrees of losses. Among these, a few fungi are causative agents of important diseases inflicting either death of the palm or gradual decline in vigour and/or yield. The diseases are described under: (1) major diseases, (2) diseases which are likely to become major in future, and (3) minor diseases. The important diseases described are bud rot, basal stem rot, stem bleeding, lethal bole rot, leaf rot etc. The paper also gives an account of the world distribution of important fungal diseases and losses caused by them. The symptomatology, etiology, epidemiology and disease management of major diseases are described in brief. The future lines of work are also outlined at the end. A coordinated approach in research on coconut diseases on a regional basis should receive attention so that there is free exchange of information and expertise between these countries. Investigations on disease management including reaction of varieties to important diseases of coconut should be a priority in the research programmes of different coconut research institutes.

INTRODUCTION

Coconut cultivation runs the risk of being affected by various diseases in many parts of the world. A wide array of fungi attack different parts of coconut namely, crown, stem or root. Among the 173 fungal species reported from coconut (Joseph and Radha, 1979 b), only a few cause serious disease problems and are difficult to control effectively. Joseph and Radha (1979 a) had attempted earlier to enlist the species of fungi and fungal diseases recorded on coconut. Only important fungal diseases on coconut are discussed in this paper.

In India, bud rot, Thanjavur wilt (Basal stem rot or *Ganoderma* wilt), leaf rot and stem bleeding are important coconut diseases of fungal etiology. In Indonesia, *Phytophthora* rots, stem bleeding and leaf spots are responsible for losses in hybrid coconuts (Sitepu and Darwis, 1989). There are many types of

leaf spots reported from different parts of the world and are of less importance. The losses caused by some important fungal diseases of coconut are presented in Table 72.1.

Table 72.1: Loss due to important fungal diseases of coconut

Disease	Causative organism	Country	Loss/incidence	Reference
Bud rot	<i>Phytophthora palmivora</i>	India	0.1–10%	Radha and Joseph (1974)
		Jamaica	2.5%	Nowell (1925)
		Philippines	6.7%	Rillo and Paloma (1989)
		Indonesia	50% (in hybrids)	Sitepu and Darwis (1989)
		Ivory Coast	50%	Quillec <i>et al.</i> (1984)
		Sri Lanka	Not wide-spread	Mahindapala (1989)
Basal stem rot	<i>Ganoderma lucidum</i>	India	2.6–13.5%	Rethinam (1984)
	<i>G. applanatum</i>	(Tamil Nadu)		
	<i>G. boninense</i>	Sri Lanka	Not a major disease	Mahindapala (1989)
Stem bleeding	<i>Thielaviopsis paradoxa</i>	Indonesia	Not serious	Sitepu and Darwis (1989)
Leaf rot	<i>Bipolaris halodes</i> <i>B. incurvata</i>	India	8.8%	Anonymous (1990)
		Papua New Guinea	Upto 70% seedlings affected	Radha <i>et al.</i> (1962)
		Guinea		Gallasch (1974)
Lethal bole rot	<i>Marasmiellus cocophilus</i>	Kenya	20–30% incidence in nurseries	Bock <i>et al.</i> (1970)
	<i>M. inoderma</i>	Tanzania		Jackson and Firman (1979)
		Solomon Is.		
		Malaysia		

* Limited survey in Kannur and Kasaragod districts in Kerala.

The fungal diseases are described under three major heads namely, (i) major diseases, (ii) diseases which are likely to become major in future, and (iii) minor diseases. In the first category bud rot, basal stem rot and stem bleeding are included while in the second category leaf rot and lethal bole rot are discussed. Different categories of leaf spot, fruit rot, thread blight, etc. are included in minor diseases.

MAJOR FUNGAL DISEASES

Bud Rot

The disease is the common killer disease of coconut reported from many coconut growing countries, and was first reported from Grand Cayman (West Indies) in 1834 (Tucker, 1926). Subsequently the disease was reported from Cuba, India, the Philippines, Jamaica, East Africa, Fiji, Papua New Guinea, Sri Lanka etc.

The disease is sporadic in nature though outbreaks of epidemics are also not uncommon (Radha and Joseph, 1983). Losses up to 2.5 per cent have been reported in Jamaica (Nowell, 1925), while Radha and Joseph (1974) reported

0.1 to 10 per cent in various states of India. Occasional heavy incidence (35 to 40 per cent) also has been observed in Kerala and Karnataka by these authors.

Symptomatology: The first externally visible symptom is the withering of the spear leaf which subsequently turns brown and bends. In course of time, the younger leaves closer to the spindle also show similar symptoms. The internal tissues show discolouration, assuming pale pink colour with a brown border (Quillec *et al.*, 1984). The base of the spindle is rotten and can be detached with a gentle pull. It emits a foul smell. One by one, the inner leaves also fall away leaving only mature leaves in the lower whorl at the trunk apex. The palm ultimately succumbs to the disease (Menon and Pandalai, 1958).

The pathogen: Butler (1906) and Shaw and Sundararaman (1914) reported the causal organism as *Phytophthora palmivora* Butl.; *P. faberi* Maubl. was found to be the causal agent in the Philippines (Reinking, 1919); *P. heveae* in Ivory Coast and French Polynesia (Franquivelle *et al.*, 1989; Quillec and Renard, 1984); while *P. parasitica* was found to be the causal agent in Costa Rica and *P. nicotianae* in Indonesia (de Nuce de Lamothe, 1988; Coffey *et al.*, 1990). These pathogens also cause lesions on nuts resulting in nut fall, quite independent of bud rot. Steer and Coates-Beckford (1990) reported that *P. katsurae* and *Thielaviopsis paradoxa* also caused bud rot in wound-inoculated seedlings. Joseph and Radha (1975) and Quillec *et al.* (1984) observed from inoculation studies that other fungal species like *Fusarium* spp. or bacteria like *Erwinia*, *Pseudomonas* or *Xanthomonas* are only secondary saprophytic colonisers. Inoculation with sporangial suspension of *P. palmivora* could induce bud rot symptoms in both the laboratory and in the field in two- to six-year-old seedlings (Joseph and Radha, 1975). Thomas *et al.* (1947) observed presence of both 'plus' and 'minus' strains of the pathogen which on pairing produced oospores. Kumar and Hegde (1987) however, found that the coconut isolates belonged to A₂ mating types.

Epidemiology: Radha and Joseph (1974) reported that relative humidity and rainfall are more related to fungal infection and disease development. It took a minimum of five weeks for manifestation of symptoms on artificial inoculation (Radha and Joseph, 1974). Rillo and Paloma (1989) found that in the Philippines higher incidence of *Phytophthora* was always preceded by higher rainfall during the previous months. The disease was found to be mainly confined to young palms below 25 years (Quillec *et al.*, 1984).

The fungus was found to survive in the frond bases or basal part of the crown (Menon and Pandalai, 1958; Radha and Joseph, 1974) or in roots (Harris *et al.*, 1984). The fungus was found to infect arecanut, oil palm, rubber, jack, cacao, cardamom, *Washingtonia* etc. on cross-inoculation (Das and Cheeran, 1986).

Disease management: Curative measures could save the palm if the disease is diagnosed in the early stages. The appropriate period would be the stage when the spindle has just started showing symptoms of withering. Menon and Pandalai (1958) and Peiris (1962) have described in detail the method of removal of the infected tissues, application of Bordeaux paste etc. Care should be taken while using copper fungicides on dwarf palms, since phytotoxic

symptoms have been observed in some dwarfs (Schut, 1975). The authors have found that Dithane M-45 can be used effectively in such cases. Other fungicides advocated earlier against bud rot disease include phenyl mercury urea applied in the form of powder or pellets in leaf axils (Peiris, 1962) or Demosan spray (Radha and Joseph, 1974), or stem injection or root infusion of Aliette or Ridomil or phosphorous acid (Coffey *et al.*, 1990). However, these are quite expensive. Mahindapala (1989) suggested use of copper fungicide mixed with coir dust taken in muslin cloth and kept in axils for the control. One of us (KKNN) has observed that Dithane M-45 mixed with saw dust and taken in a perforated polythene sachet can be kept in leaf axils of dwarf seedlings, resulting in effective control of the disease. Ohler (1984) suggested that measures like improved drainage, wide spacing and weed control would help in reducing the relative humidity resulting in an indirect prevention of disease incidence.

Quillec *et al.* (1984) observed that hybrids were less sensitive to the disease than West African Tall. However, Brahmana and Kelana (1988) found dwarf palms more sensitive while others were highly tolerant. Rillo and Paloma (1989) found that *Phytophthora* incidence was higher in Cameroon Red Dwarf, MYD etc. as compared to Catigan, MYD $\times$ WAT etc. Bennett *et al.* (1986) found that Nias Yellow Dwarf were highly susceptible. Since Nias Dwarfs have never been reported to suffer from *Phytophthora* rots in their land of origin Nias Island, North Sumatra, the authors opined that in studying resistant characteristics environmental conditions should be taken into consideration. Coffey *et al.* (1990) reported that in Indonesia dwarf selections such as Jombang and Raja appeared to be more resistant to nut fall in inoculation trials.

Basal Stem Rot

Basal stem rot is one of the destructive diseases of coconut occurring in various coconut growing regions of the world. The disease is known as Ganoderma wilt in Andhra Pradesh, *Anabe* in Karnataka (Venkatarayan, 1936; Rao and Rao, 1966) and as Thanjavur wilt in Tamil Nadu (Vijayan and Natarajan, 1972). Peries (1974) reported the disease from Sri Lanka as 'basal stem rot'. Nambiar and Rethinam (1987) reported the disease in some pockets of Kerala also. Bhaskaran and Ramanathan (1984) found that the disease incidence ranged from 0.6 per cent to 4.9 per cent in Tamil Nadu. In severely affected gardens in Thanjavur district of Tamil Nadu, the disease incidence was as high as 31.4 per cent (Bhaskaran *et al.*, 1984).

Symptomatology: Though the root system is affected first, the visible symptom is seen in the crown as wilting of leaflets. The outer whorl of leaves turn yellowish, then gradually become brown and droop to form a skirt around the trunk apex. In course of time the apex of the trunk shows tapering with the advancement of the disease, and the stem base shows bleeding symptoms. The tissues beneath the lesions are decayed and this decay can be traced into the bole region. The drooped leaves fall off one by one leaving only a few leaves at the apex. The crown is easily blown off by wind (Bhaskaran *et al.*, 1982). At the

base of the affected palms, sporophores of *Ganoderma* spp. appear, generally after the death of the palm (Bhaskaran *et al.*, 1989). Usually it takes six months to two years for the affected palms to die (Rethinam, 1984).

The pathogen: In India, *Ganoderma lucidum* was reported to be the causative agent of the disease (Rao and Rao, 1966). However, later reports (Bhaskaran *et al.*, 1989) show that *G. applanatum* is also involved. Peries *et al.* (1975) on the other hand reported *G. boninense* as the causal agent of basal stem rot in Sri Lanka. However, the pathogenicity still remains to be established by artificial inoculation.

Epidemiology: Rao and Rao (1966) reported less incidence of the disease in heavy soils of Andhra Pradesh, probably due to their high moisture retention capacity. Peries *et al.* (1975) also found that the disease progressed rapidly in dry areas, the destruction of the palm being faster (six to 30 months) in areas receiving less rainfall (1000 mm) as compared to areas receiving 2000 mm rainfall (up to six years). Lewin *et al.* (1983) reported that soil moisture stress during the summer predisposed the palms to infection. A positive correlation between mean maximum temperature and the number of bleeding palms has been observed by Jagannathan and Ramasamy (1975). Vijayan and Natarajan (1972) reported that trees in the age group of 10 to 30 years were more susceptible. The disease spread was from a central point towards outside and the linear spread was found to be influenced by low rainfall and relative humidity (Ramapandu *et al.*, 1980).

Early detection: Since diagnosis of the disease at a very early stage is essential for taking up effective control measures, some work has been done in this line. Colorimetric methods (Natarajan *et al.*, 1986) or methods employing physiological parameters like transpiration rate and stomatal diffusive resistance (Vijayaraghavan *et al.*, 1987) have given encouraging results. Diagnostic method using fluorescent antibody technique developed against *Ganoderma* disease in arecanut (Reddy and Ananthanarayanan, 1984) is being employed in coconut also (Anonymous, 1991).

Disease management: Destruction of the bole of the diseased palm and isolation of healthy palms was suggested by Briton-Jones (1940) and Nambiar and Rethinam (1987), while Peries *et al.* (1975) recommended removal of the affected tissues and applying fungicides. Ploughing and flood irrigation should be avoided to prevent the spread of infective propagules. Irrigation may be provided through drip or channel. Application of neem cake at 5 kg per palm was found to be beneficial in inhibiting the disease (Bhaskaran *et al.*, 1988). The use of *Trichoderma* spp. for the biological control of the pathogen has been reported (Bhaskaran *et al.*, 1989). Among the fungicides, Aureofungin-sol and calixin have been reported to give very encouraging results.

Stem Bleeding Disease

The disease was first reported from Sri Lanka (Petch, 1906) and later from India, the Philippines, Malaysia, Trinidad, Fiji, Indonesia etc. The disease has been found to occur in all soil types, but more in laterite and sandy soils. Serious infection was found to lead to reduced yield (Nambiar and Sastry,

1988). In Indonesia stem bleeding causes severe damage to PB-121 hybrid and affects yield (Kartika *et al.*, 1984).

Symptomatology: As the very name of the disease indicates, the characteristic symptom is the presence of bleeding patches on the stem. In the initial stage, dark brown small lesions develop at the base of the trunk, which gradually progress upwards. A dark reddish-brown liquid exudes from the longitudinal growth cracks on the stem. These lesions may coalesce to form larger lesions. The exudate dries up in course of time to form black encrustations with underlying tissues being disintegrated and fibrous. This process is fast in young palms. As a result of the degradation, cavities are formed on the trunk. The leaves also show gradual yellowing in the outer whorl, rather prematurely, then droop and dry up. The trunk gradually tapers towards the apex and the crown size is reduced. Crown symptoms are more pronounced during the summer season. Mathew *et al.* (1989) described a method of indexing the disease severity.

The pathogen: *Thielaviopsis paradoxa* (de Seynes) von Hohnel has been reported to be the pathogen involved in the disease (Briton-Jones, 1940; Nambiar *et al.*, 1986; Sitepu and Darvis, 1989). Though *Phomopsis cocoina* Cke (Punith) and *Schizophyllum commune* Fr. have been recorded from affected stems, their pathogenicity could not be established (Lily 1984a; 1984b). *T. paradoxa* was also isolated from nuts showing gummosis and splitting (Nambiar, unpubl.). Inoculation studies showed that infection by the fungus was faster on the trunk during wet and cooler months (July to November) when high humidity and moderate temperature prevail (Nambiar *et al.*, 1989). The optimum temperature for mycelial growth was found to be 28°C (Milanes and Herrera, 1986) while Nishitha Naik (1990) found that it was 30°C. Anil Kumar and Nambiar (1990) reported the effect of certain physical and chemical factors on spore germination. An efficient method of isolation of the fungus from coconut stem tissues and soil was also reported by these authors (Anil Kumar and Nambiar, 1991).

Epidemiology: The fungus is a weak pathogen and enters the trunk through a wound or growth cracks (Briton-Jones, 1940). Splits are known to develop on the stem after sudden heavy rains preceded by prolonged dry period (Ohler, 1984) or after heavy manuring (Briton-Jones, 1940) or trash burning (Nambiar and Sastry, 1988). Salgado (1942) and Sulladmath *et al.* (1980) suggested that poor drainage, imbalanced mineral nutrition or other physiological disorders might be other predisposing factors. Though Potty and Radhakrishnan (1978) found that increased levels of P caused increased disease incidence, Mathew and Ramanandan (1980) could not observe any significant difference in the major nutrient content between healthy and diseased palms. Nor could they find any relation between disease and soil pH or electrical conductivity. In Indonesia, chlorine deficiency is reported to be associated with the disease and correction of this deficiency was found to prevent the disease (Van Uexkull, 1985). Nagarajan (1985) reported that excessive salinity with high sodium during summer was associated with the disease. Radhakrishnan (1987) reported maximum symptoms under natural conditions in July and the least in summer months. Nambiar *et al.* (1989) observed from inoculation trials maximum infection during July to November.

Disease Management: Till recently, the control measures adopted by the farmers were mainly phytosanitation and application of hot coal tar or Bordeaux paste to the affected patch on the trunk from where the dead and decayed tissues have been removed by chiselling. Root feeding or drenching carbendazim or tridemorph were found effective recently in controlling the disease (Nambiar and Sastry, 1988; Radhakrishnan, 1990). Summer irrigation may be provided to reduce prolonged moisture stress. Along with normally recommended organics and fertilisers, *neem* cake may be added at the rate of 5 kg per palm to increase soil microflora including *Trichoderma* spp. which inhibits the growth of the pathogen *in vitro* (Gowda and Nambiar, 1991) and in detached frond tissues (Usman, 1988; Sanal Kumar, 1990).

OTHER IMPORTANT DISEASES

Leaf rot and lethal bole rot are two diseases of coconut now observed sporadically, often causing serious economic losses.

Leaf Rot Disease

Leaf rot disease was reported (Menon and Nair, 1948) to be present in Southern Kerala during the last century itself. Palms affected by root (wilt) disease were found to be generally superimposed by this fungal disease (Radha and Lal, 1968). The yield loss in root (wilt) affected palms is mainly due to incidence of leaf rot (Radha *et al.*, 1962). In Papua New Guinea, Gallasch (1979) observed a similar foliar disease and called it the leaf spot disease. Nursery seedlings and young palms have been found to be affected by this fungal disease (Ferreira and Leal, 1987). Era and Celino (1972) observed severe incidence of the disease in Laguna plantations. Recently the disease has been reported in the exotic collections of World Coconut Germplasm Centre in the Andamans (Rao, 1988 a).

The symptomatology has been described in detail in a recent review by Joseph and Rawther (1991). Reddish-brown minute sunken spots and water soaked lesions appear on the spindle and tender leaves. The lesions enlarge and soft rot develops gradually. The tips of leaflets and margins become decayed. The rotting subsequently spread extensively within the spindle and tender leaves. The successively emerging spindles are also attacked by leaf rot. These affected tissues break off when dried and are blown off by wind leaving only the midrib giving a fan-like appearance to the affected leaves. When the attack is on the older leaves, the symptoms appear as leaf spots rather than leaf rots. Fungi like *Helminthosporium halodes* = *Bipolaris halodes* (Drechs) Shoemaker, *Gloeosporium* sp., *Gliocladium roseum*, *Curvularia* sp., *Diplodia* sp., *Pestalotia* sp., and *Fusarium* sp. were isolated (Menon and Nair, 1948). Menon and Nair (1951) in elaborate pathogenicity trials found that *H. halodes* is the most virulent pathogen among the fungi tested and the rest are only secondary parasites aggravating the rotting initiated by *H. halodes*. Radha and Lal (1968) reported the presence of *H. halodes* from Kasaragod, a root (wilt)-free area.

Nadakal (1965) found *Panagrolaimus* sp., a nematode on leaf tissues of palms affected by diseases including leaf rot.

The disease incidence is favoured by high humidity and low temperature (Menon and Nair, 1951; Radha *et al.*, 1961). They also found that while nitrogenous fertilisers in high dose are favourable for the disease incidence, potassic fertilisers increased the resistance of palms. George and Samraj (1966) suggested boron deficiency as a factor responsible for the disease development since coconut palms affected by leaf rot responded favourably to boric acid application. However, Radha (1965) could not observe such alleviation of symptoms when boron was applied. Lily (1963) reported that the tender most leaf was highly susceptible.

Nair and Radha (1959) and Radha (1961) found that regular manuring and spraying with copper fungicides checked the disease. While Gregory (1960) found aerial spraying of oil based copper fungicides useful in controlling the disease, Samraj *et al.* (1966) could get only contradictory results. Gallasch (1979) advocated spraying with Duter 0.04 per cent concentration. Spraying of leaves sequentially with Bordeaux mixture 1 per cent, Dithane M-45 0.3 per cent and Fytolan 0.5 per cent at quarterly intervals, after removing all severely affected leaves was found to reduce further incidence of the disease in affected palms (Anonymous, 1982).

Lethal Bole Rot

The disease was first noticed in Kenya and Tanzania and was reported to reach epidemic proportions in several areas along the coasts of these countries (Bock *et al.*, 1970). Later Jackson and Firman (1979) reported the disease from Solomon Islands and Holliday (1980) from Madagascar. The disease mainly affects young palms in the field or seedlings in the nursery. A survey conducted in Kenya and Tanzania between 1967 and 1969 showed that 5 to 20 per cent of palms were dead due to the disease.

The characteristic diagnostic symptom of the disease is the presence of a dry, reddish-brown rot at the base of the bole. Around the decay, there is a distinctive yellowish margin, 0.5 to 1.0 cm wide. The symptoms are more pronounced in two- to four-year-old seedlings. In seedlings, the presence of white mycelium was noted in cavities in the area of rot. However, in mature palms, mycelial colonisation proceeds rather slowly. The crown shows symptoms of general wilt and the leaves turn yellowish. In older palms, the outer whorl of leaves droop leaving an erect tuft of wilted, drying leaves. In the nursery the infected seedlings produce short leaves which unfold before emerging fully. A foul odour is emitted from the inner whorl of leaves as a result of soft rot in the tissues.

The causal fungus is *Marasmiellus cocophilus* (Pegler) (Bock *et al.*, 1970). Sporophores occur on exposed roots and leaf bases at ground level in seedlings. The coconut debris in the soil is also colonised by the fungus. Bock *et al.* (1970) found that the fungus gained access only through wounds in the roots. *Marasmiellus* spp. have been known to cause preemergence shoot rot of coconuts in Malaysia (Tey and Chan, 1980) and in Solomon Islands (Jackson

and Firman, 1982). The important species are *M. inoderma*, *M. palmivorus*, *M. cocophilus*, *M. albofuscus*, *M. crinisequi* and *M. semiustus*. *M. inoderma* colonises on the husk, infects the embryo and invades the cavity (Jackson and Firman, 1979). *M. palmivorus* was found to attack germinating nuts in Malaysia causing 20 to 30 per cent losses (Tey and Chan, 1980).

Dipping seednuts, after partial husking at the top, for 15 minutes in 250 ppm phenyl mercury acetate was recommended to control preemergence root rot (Jackson and Firman, 1982). Strict quarantine measures are to be followed to prevent transportation of affected seeds/seedlings to healthy areas/countries. Nuiati variety was reported to be resistant to *M. inoderma*.

FUNGAL DISEASES OF MINOR IMPORTANCE

Grey Leaf Spot

The disease also known as leaf blight is widespread in all coconut growing countries. It was reported from Cuba (Horne, 1908) and from British Guyana. The disease was later reported from Malaysia, New Hebrides, Sri Lanka, India, Trinidad, Nigeria etc. (Menon and Pandalai, 1958; Obazee and Ikozun, 1985).

Symptoms develop on leaflets of the outer whorl of leaves as minute yellow oval spots encircled by a grey brown margin. Many such spots may coalesce to form larger patches. The centre of the spots becomes greyish-white. The leaves in advanced stages of disease present a blighted appearance and hence the name leaf blight.

The disease is caused by a fungus *Pestalotiopsis palmarum* (Cooke) Stey. This is a weak pathogen. Fernando and Mahindapala (1977) could not establish the pathogenicity of the fungus in inoculation experiments. Brown (1975) found that the fungus appears as black minute specks. Many other species of *Pestalotiopsis* have been reported to be associated with leaf spot (Brown, 1973). Abad and Magat (1977) opined that the disease incidence indicated poor nutritional status of affected palms. Alonzo and Palomar (1980) reported that potassium deficiency increased the blight.

Application of balanced fertiliser, provision of adequate shade in the nurseries, and prophylactic spraying with Bordeaux mixture have been recommended by many workers to control the disease (Menon and Pandalai, 1958; Britton-Jones, 1940). Regular application of potassium chloride was reported to reduce the disease incidence (Abad *et al.*, 1978 a). Alonzo and Palomar (1980) reported that application of sea water or sea weed salt reduced leaf spot in seedlings. Das and Mahanta (1985) found that carbendazim, thiabendazole and thiram inhibited the growth of the pathogen. Abad *et al.* (1978 b) reported that 'Catigar' variety showed consistent tolerance to the disease. In Indonesia, Khina-1, Khina-3, Markham Tall etc. are considered to have low susceptibility to this disease (Sitepu and Darwis, 1985 a). Rao (1988 b) found that cultivar 'Katchal' grown in the Andamans was more tolerant compared to other cultivars.

Fruit Rot

Fruit rot or nut fall was recorded from India (Sundararaman and Ramakrishnan, 1924), Malaysia (Turner, 1965), Colombia (Sanchez Potes, 1966), and Indonesia (Bennett *et al.*, 1986). The disease is characterised by rotting of immature nuts during the rainy season, resulting in nut fall. Water soaked lesions develop at the stalk end of nuts. These lesions turn brown and become sunken due to decay of underlying tissues. The rot extends into the husk sometimes deep into the endosperm cavity of the shell which has not hardened.

The disease is caused by *Phytophthora palmivora*. Bennett *et al.* (1986) found in inoculation trials that the rate of lesion growth was inversely proportional to the age of nuts. The pathogen also causes bud rot. The disease can be effectively prevented by prophylactic spray with Bordeaux mixture 1 per cent during the pre-monsoon period.

Sulladmath and Shantappa (1979) recorded immature nut fall in Karnataka in India caused by another fungus *Botryosphaeria rhodina* (Berk and Curt.) V. Arx. In Brazil, Almeida Jr. and Aquino (1978) reported fruit rot caused by *Colletotrichum gloeosporioides* Penz. The disease mainly affects harvested fruits, causing 1.5 to 41 per cent incidence. The affected fruits are desiccated and deformed showing longitudinal fissures. *Colletotrichum* spp. are known to cause nut splitting in Kenya (cited by Menon and Pandalai, 1958). In India, *C. cingulata* and *C. paucisetum* are known to cause leaf spot (Johnston, 1965).

Petiole Disease/Petiole Rot

The disease was first recorded from Sri Lanka (Stockdale, 1907; Gadd, 1920) and later from Malaysia, Papua New Guinea and New Caledonia. Recently, Sulladmath and Ponnappa (1978) recorded the disease from Karnataka state, India.

Dark, chocolate brown, irregular or circular lesions appear on the adaxial surface of the petiole. Isolated raised blisters also appear. Two or more lesions merge to form larger ones. The affected petioles break at the point of the lesions and broken dry fronds hang down. The disease is caused by *Anthrostomella cylindrospora* Booth and Shaw and *A. fusispora* Booth and Shaw (Booth and Shaw, 1967). Sivanesan *et al.* (1976) described *Leiosphaerella longispora* from lesions on the coconut petioles which collapsed due to drought in Papua New Guinea. In Jamaica, Ashby (1920) isolated *Phytophthora* sp. from lesions on the petiole showing 'leaf stalk rot' symptoms. The authors have isolated *P. palmivora* and *Thielaviopsis paradoxa* from such affected petioles of coconut in some areas of Kerala and Karnataka.

Leaf Spots

Many types of leaf spot diseases have been described to affect coconut leaves. They are *Alternaria* leaf spot (Rao and Subramanyan, 1975), *Curvularia* leaf spot (Chan, 1974) *Exosporium* leaf spots (Mittra, 1929), oval leaf spot (Stevens, 1932) etc. *Alternaria* leaf spot first described from Andhra Pradesh (Rao and Subramanyan, 1975) is generally seen on one to three-year-old

coconut seedlings as black round or oval spots. The causal agent is *Alternaria alternata* (Fr) Keissler. Recently this fungus has been noticed in some coconut gardens in Kerala. Mishra (1987) recorded *A. tenuissima* from affected leaves. Radha and Menon (1954) reported *Curvularia* sp. from leaves of root (wilt) affected palms. Chan (1974) isolated *C. maculans* from the lesions on leaves in Malaysia. The disease is serious in seedlings grown under shade and spreads rapidly under high humid conditions (Tey and Chan, 1980). Chan (1974) found that spraying the affected seedlings with captan or Difolatan controlled *Curvularia* leaf spot. *Exosporium* leaf spot is caused by *E. durum* (Johnston, 1965) and *E. palmivorum* (Mitra, 1929). Jet black wart like fructifications are seen on the affected leaf surface. The disease occurs on palms under neglect. Oval leaf spot has been reported from Philippines, Samoa, Papua New Guinea and Indonesia, Malaysia, New Caledonia, Solomon Islands and Tonga (Johnston, 1965). The disease is characterised by small oval spots, dark tan in colour, and is caused by *Epicoccum cocos* Stevens. Infection occurs through insect injuries. Rao and Renukumar (1989) reported a leaf spot disease caused by *Cercospora apii* Fr. occurring on seedlings in South Andamans. Sooty mould caused by *Capnodium footii* or *Aithaloderma setosum* have been reported from the Philippines, Malaysia, Solomon Islands, etc. (Johnston, 1965). Sooty mould can be controlled by spraying an emulsion consisting of soap, kerosene and water (225 g soap, 4.5 l water and 9 l kerosene) and the emulsion is diluted to 1:9 water while spraying.

White Thread Blight

This disease has been recorded from Papua New Guinea, Sri Lanka, Fiji, New Hebrides and New Britain. The disease is characterised by the appearance of large circular necrotic patches on the upper surface of leaflets of older leaves. White mycelial threads are seen on the under-surface of leaflets, along the midrib and the affected tissues are killed. The disease is caused by *Corticium penicillatum* Petch. Tey and Chan (1980) found that *Corticium* sp. caused leaf blotch in seedlings in Malaysia. Avoiding overcrowding in the garden, pruning severely affected leaves and spraying Bordeaux mixture helped to control the disease (Douglas, 1965).

Post-Harvest Diseases

The important fungi attacking copra are *Aspergillus niger*, *A. glaucus*, *A. flavus*, *A. fumigatus* and *A. ochraceous* (Ward, 1937), *Ceratostomella adiposum* (Thompson, 1933), *Botryodiplodia theobromae* and *Rhizopus oryzae* (Rao et al., 1971), *Penicillium frequentas* (Nair and Nathan, 1971), *Endosporostilbe* sp. (Patil and Kelkar, 1975), *Penicillium citrinum* (Susamma and Menon, 1983), *Tabutia cocoicola* (Sivanesan, 1979) and *Drechslera hawaiiensis* (Sharma et al., 1985). Fernandez (1988) reported fungi viz., *Thielaviopsis*, *Cephalosporium*, *Microsporium*, *Botrytis* and *Fusarium* from the thin layers external to the endocarp. *Thielaviopsis paradoxa* has been recently noticed in copra and the shell of coconut in India (Nambiar, unpubl.). Susamma et al. (1980) found that monsoon periods favoured the development of fungi on copra. Moisture

content of above 5 per cent in copra permitted fungal invasion (Pusposindjojo and Christensen 1977). Susamma and Menon (1983) reported that copra having 5 per cent moisture and kept in gunny bags lined with polythene sheet remained moderately free of infection.

CONCLUSION

In a perennial tree crop like coconut, disease control is difficult. In the case of basal stem rot, by the time the disease is diagnosed, often the disease would have advanced into the last stage when adoption of curative measures may not have yielded the desired results. Under such circumstances, a method for early diagnosis of the disease would have to be evolved. A beginning has been made in this line at this Institute using fluorescent antibody technique. The relationship between *Ganoderma* spp. occurring in different palms will have to be studied using serological methods and also based on the protein band difference.

Methods to apply systemic fungicides easily into the palm trunk through stem injectors or as encapsulated chemicals placed in bore holes in the trunk can be developed.

There should be strict quarantine regulations not only between countries, but within a country also. Transport of planting materials from diseased areas to the healthy areas should be prevented by law as also by educating the farmers.

In a crop like coconut, which is committed to the land for a long duration, use of resistant varieties against diseases is likely to be the most promising way of tackling them and hence should receive priority. This is especially necessary when the cost of inputs including that of fungicides is increasing day by day. It is a happy augury that work in this line is in progress in India to develop tolerant varieties to coconut diseases.

REFERENCES

- Abad, R.G. and Magat, S.S. 1977. Effect of KCl fertilisation on coconut leaf spot disease and yield. *Philipp. Phytopath.* 3: 74-77.
- Abad, R.G., Gallego, V.C. and David, J.R. 1978 a. Reaction of some coconut populations to leaf spot disease at the nursery stage. *Philipp. J. Cocon. Studies* 3(3): 21-27.
- Abad, R.G., Prudente, R.L. and Magat, S.S. 1978 b. Incidence of leaf spot in coconut fertilised with various combinations of nitrogen, phosphorus and potassium chloride. *Philipp. J. Cocon. Studies* 3(1): 37-44.
- Almeida, Jr. J.L. De and Aquino, M. De L.N. 1978. Anthracnose or fruit rot of coconut palm (*Cocos nucifera* L.) in Pernambuco State. *Pesquisa Agropecuaria Pernambucana* 2(1): 37-44.
- Alonzo, J.C. and Palomar, M.K. 1980. Effect of sea water and sea weed salt on coconut grey leaf spot disease. *Philipp. J. Cocon. Studies* 5(2): 27-32.
- Anil Kumar and Nambiar, K.K.N. 1990. Effect of certain physical and chemical factors on the germination of endoconidia and chlamydospores of *Thielaviopsis paradoxa*. *Indian Phytopath.* 43: 460-462.
- Anil Kumar and Nambiar, K.K.N. 1991. An improved method of isolation of *Thielaviopsis paradoxa* from stem bleeding affected coconut palms. *CORD* 7: 49-53.
- Anonymous, 1982. Central Plantation Crops Research Institute, Annual Report for 1979, CPCRI, Kasaragod. pp. 276.

- Anonymous. 1988. Central Plantation Crops Research Institute, Annual Report for 1987, CPCRI, Kasaragod. pp. 186.
- Anonymous. 1990. Central Plantation Crops Research Institute, Annual Report for 1989-90. CPCRI, Kasaragod. pp. 262
- Anonymous. 1991. Central Plantation Crops Research Institute, Annual Report for 1990-91. CPCRI, Kasaragod. pp. 154.
- Ashby, S.F. 1920. Notes on two diseases of the coconut palm in Jamaica caused by the fungi of the genus *Phytophthora*. *Trop. Agriculturist* 55: 162-167.
- Bennett, C.P.A., Roboth, O., Sitepu, G. and Lolong, A. 1986. Pathogenicity of *Phytophthora palmivora* (Butl.) Butl. causing premature nutfall of coconut (*Cocos nucifera* L.) *Indonesian J. Crop Sci.* 2(2): 59-70.
- Bhaskaran, R. and Ramanathan, T. 1984. Occurrence and spread of Thanjavur wilt disease of coconut. *Indian Cocon. J.* 15(6): 1-3.
- Bhaskaran, R., Chandrasekhar, G. and Ramanathan, T. 1984. Survey and epidemiology of Thanjavur wilt of coconut. In: *Proc. All India Symp. on Coconut Diseases*, Coconut Res. Station, Veppankulam. pp. 14-18.
- Bhaskaran, R., Ramadoss, N. and Ramachandran, T.K. 1988. Biological control of Thanjavur wilt disease of coconut. *Indian Cocon. J.* 19(6): 3-8.
- Bhaskaran, R., Ramanathan, T. and Ramaiah, M. 1982. The Thanjavur wilt. *Intensive Agric.* 9: 19-21.
- Bhaskaran, R., Ramanathan, T. and Ramaiah, M. 1984. Thanjavur wilt of coconut: Its occurrence, spread and management. In: *Proc. Placosym VI*. Indian Society for Plantation Crops, Kasaragod, Kerala. pp. 107-113.
- Bhaskaran, R., Rethinam, P. and Nambiar, K.K.N. 1989. Thanjavur wilt of coconut. *J. Plantn. Crops* 17: 69-79.
- Bock, K.R., Ivory, M.H. and Adams, B.R. 1970. Lethal bole rot disease of coconut in East Africa. *Ann. Appl. Biol.* 66: 453-464.
- Booth, C. and Shaw, D.E. 1967. *Anthostomella fusispora* sp. nov. and *A. cylindrospora* sp. nov. on *Cocos nucifera*. *PNG Agric. J.* 19: 94-98.
- Brahmana, T. and Kelana, A. 1988. Bud rot disease on PB121 coconut at Bangun Purba PTP VI North Sumatra. *CORD* 4(2): 76-87.
- Britton-Jones, H.R. 1940. The diseases of the coconut palm. Ballien, Tindall & Cox, London. pp. 176.
- Brown, J.F. 1973. Diseases of coconuts in the British Solomon Islands. *Pl. Dis. Repr.* 57: 856-860.
- Brown, S. 1975. Investigations of some coconut leaf spots in Papua New Guinea. *PNG Agric. J.* 26: 31-42.
- Butler, E.J. 1906. Some diseases of palms. *Agric. J. India* 1: 299-310.
- Chan, C.L. 1974. Chemical control of *Curvularia* leaf spot of coconut seedlings. *MARDI Res. Bull* 2(1): 19-24.
- Coffey, M.D., Sitepu, D., Kharie, S., Mangindan, H., Waroka, J.S. and Motilo, H.F.J. 1990. Integrated control of *Phytophthora* bud rot and premature nutfall of coconut in Indonesia. p. 105. Abstracts in 3rd Intern. Conf. on Pl. Prot. in the Tropics, March 20-23, 1990. Pahang, Malaysia.
- Das, C.M. and Mahanta, I.C. 1985. Evaluation of some fungicides against *Pestalotia palmarum* Cke. incitant of grey blight of coconut. *Pesticides* 19(5): 37-39.
- Das, T.P.M. and Cheeran, A. 1986. Infectivity of *Phytophthora* species on cash crops in Kerala. *Agric. Res. J. Kerala* 24(1): 7-13.
- Douglas, L.A. 1965. Some aspects of coconut growing in Papua New Guinea. *PNG Agric. J.* 17: 87-91.
- Era, A.M. and Celino, M.S. 1972. *Helminthosporium* leaf spot of coconut and the effect of eradication on the fungus. *Araneta Res. J.* 19: 137-138.
- Fernandez, W.L. 1988. Microbial contamination of mature coconut fruit. *Philipp. Agriculturist* 71: 13-20.
- Fernando, P. and Mahindapala, R. 1977. Leaf blight disease of coconut. 1. Studies on *Pestalotia palmarum*. *Ceylon Cocon. Quart.* 28: 73-80.
- Ferreira, J.M.S. and Leal, E.C. 1987. Plant health protection of coconut palm. II. Control of pests and diseases in the nursery. Circular Tecnica, Centro Nacional de Pesquisa de Coco No. 6, pp. 13.

- Franqueville, H. De., Taffin, G. De., Sangare, A., Saint, J.P. Le, Pomier, M. and Renard, J.L. 1989. Detection of *Phytophthora heveae* tolerance characters in coconut in Cote d' Ivoire. *Oleagineux* 44(2): 93-103.
- Gadd, C.H. 1920. A leaf break disease of coconut. *Trop. Agr.* 55: 106-108.
- Gallasch, H.E. 1974. Effect of nutrition on the incidence of *Drechslera incurvata* leaf spot of coconuts. *PNG Agric. J.* 25: 38-50.
- Gallasch, H.E. 1979. Leaf spot disease on coconuts. *Lowlands Agr. Exp. Station Information Bull. No. 19*, Papua New Guinea. p. 2.
- George, M.K. and Samraj, J. 1966. Deficiency of boron, a possible cause of the leaf rot in coconut palm. *Agric. Res. J. Kerala* 4: 71-73.
- Gowda, P.V. and Nambiar, K.K.N. 1991. *In vitro* interaction of antagonistic fungi with *Thielaviopsis paradoxa*, the causal agent of coconut stem bleeding disease. *J. Plantn. Crops* 18(Suppl.): 233-238.
- Gregory, P.J. 1960. Protection of agricultural crop diseases and pests by aerial spraying with reference to coconut. *Indian Cocon. J.* 14: 323-330.
- Harris, D.C., Cardon, J.A., Justin, S.H.F.W. and Passey, A.J. 1984. *Phytophthora palmivora* on cultured roots of coconut. *Trans. Brit. Mycol. Soc.* 82: 249-255.
- Holliday, P. 1980. *Fungus Diseases of Tropical Crops*. Cambridge Univ. Press, Cambridge.
- Horne, W.T. 1908. The bud rot and other coconut troubles in Cuba. *Bull.* 15, Estacion Central Agronomic de Cuba.
- Jackson, G.V.H. and Firman, I.D. 1979. Coconut disease caused by *Marasmiellus cocophilus* in Solomon Islands. Information Circular, South Pacific Commission No. 83, pp. 6.
- Jackson, G.H.V. and Firman, I.D. 1982. Seed-borne marasmioid fungi of coconut. *Pl. Path.* 31: 187-188.
- Jagannathan, T. and Ramasamy, R. 1975. Fifth Annual Report, Tamil Nadu Agrl. Univ., Coimbatore, 1975-76, pp. 173.
- Johnston, A. 1965. Host list of fungi and insects recorded in the South-east Asia and Pacific Region. *Cocos nucifera* L. *Coconut Tech. Report No. 16*, 18 pp. FAO, Bangkok.
- Joseph, T. and Radha, K. 1975. Role of *Phytophthora palmivora* in bud rot of coconut. *Pl. Dis. Repr.* 59: 1014-1017.
- Joseph, T. and Radha, K. 1979 a. Fungi associated with the coconut palm. pp. 51-91. In: *Nematodes, Fungi, Insects and Mites Associated with the Coconut-Palm*. Tech. Bull. 2. pp. 236.
- Joseph, T. and Radha, K. 1979 b. Coconut diseases and quarantine regulations. *Technical Document FAO Pl. Prot. Comm. for the South East Asia & Pacific Region No. 118*, pp. 14.
- Joseph, T. and Rawther, T.S.S. 1991. Leaf rot disease. pp 81-88. In: *Coconut Root (wilt) Disease* Nair M.K. and others (Eds.) CPCRI, Kasaragod. pp. 92.
- Kartika, D., Soebagio, F.X., Turner, P.D. and Breure, C.J. 1984. Severe stem bleeding and frond fracture of MAWA hybrid coconut in North Sumatra. Paper 51, Intern. Conf. on Cocoa and Coconut, Malaysia. pp. 14.
- Kumar, P.S. and Hegde, R.K. 1987. Studies on *Phytophthora* diseases of plantation crops. *Pl. Path. Newsletter* 5(1-2): 28.
- Lewin, H.D., Mathar, A.S. and Sethuraman, V. 1983. Effect of different fungicides on the control of Thanjavur wilt disease of coconut. In: *Proc. National Seminar on Management of Diseases of Oilseed Crops*. Madurai, India, TNAU. pp. 99-100.
- Lily, V.G. 1963. Host parasite relations of *Helminthosporium halodes* on coconut palm. *Indian Cocon. J.* 16: 149-153.
- Lily, V.G. 1984a. Record of *Phomopsis cocoina* in stem bleeding affected palm. *Curr. Sci.* 53: 705-706.
- Lily, V.G. 1984b. *Schizophyllum commune* Fr. record from India on stem bleeding affected coconut palm. *Curr. Sci.* 53: 1299-1300.
- Mahindapala, R. 1989. Status of coconut diseases in Sri Lanka. In: *Proc. 26th Cocotech Meeting* p. 236-251.
- Mathew, A.S. and Ramanandan, P.L. 1980. Incidence of stem bleeding disease of coconut palm in relation to pH and electrical conductivity in soils. *J. Plantn. Crops* 8: 40-42.
- Mathew, J., Nambiar, K.K.N., Jose, C.T. and Anil Kumar. 1989. Stem bleeding disease of coconut — A method for indexing the disease severity. *J. Plantn. Crops* 17: 80-84.
- Menon, K.P.V. and Nair, U.K. 1948. The leaf rot diseases of coconuts in Travancore and Cochin. *Indian Cocon. J.* 1(2): 33-39.

- Menon, K.P.V. and Nair, U.K. 1951. Scheme for the investigations of the root and leaf diseases of the coconut palm in South India. Consolidated final report of the work done from 8th March 1937 to 31st March 1948. *Indian Cocon. J.* 5(1): 3-19.
- Menon, K.P.V. and Pandalai, K.M. 1958. The Coconut Palm — A Monograph. Indian Central Coconut Committee, Ernakulam. pp. 384.
- Milanes, V.P. and Herrera, I.L. 1986. Effect of temperature on the growth and pathogenic activity of *Thielaviopsis paradoxa* (de Seynes) Mor. *Centro Agricola* 13(2): 24-28.
- Mishra, D. 1987. New host records of fungi from India. *Indian J. Mycol. Pl. Path.* 17(2): 236.
- Mitra, M. 1929. Some diseases of crops in Andaman Islands. *Agric. Res. Inst. Pusa Bull.* 195: pp. 14.
- Nadakal, A.M. 1965. A note on the occurrence of nematodes of the leaves of coconut palms in Kerala. *Sci. Cult.* 31: 157-158.
- Nagarajan, M. 1985. Influence of saline environment on the incidence of stem bleeding in coconut (*Cocos nucifera* L.). *Sci. Cult.* 51: 349-351.
- Nair, U.K. and Radha, K. 1959. Manuring-cum-spraying for the control of coconut palm diseases. In: *Proc. 1st Conf. Cocon. Res. Workers, Trivandrum, India.* pp. 250-254.
- Nair, M.C. and Nathan, H.C. 1971. Spoilage of copra by *Penicillium frequentans* Westling. *Agric. Res. J. Kerala* 8(2): 125.
- Nambiar, K.K.N. and Rethinam, P. 1987. Thanjavur wilt disease of coconut comes to Kerala. p. 19. *Abst. Intern. Symp. on Ganoderma wilt diseases of palms and other perennial crops.* 6-8 Jan. 1987, Thanjavur, India. pp. 28.
- Nambiar, K.K.N. and Sastry, K. 1988. Stem bleeding disease of coconut. Current status and approaches for control. *Philipp. J. Cocon. Studies* 13(1): 30-32.
- Nambiar, K.K.N., Anil Kumar, Sastry, K. and Joshi, Y. 1989. Seasonal effect of infection by coconut stem bleeding pathogen *Thielaviopsis paradoxa*. *Curr. Sci.* 58: 34-35.
- Nambiar, K.K.N., Joshi, Y., Venugopal, M.N. and Mohan, R.C. 1986. Stem bleeding disease of coconut: reproduction of symptoms by inoculation with *Thielaviopsis paradoxa*. *J. Plant. Crops* 14: 130-133.
- Natarajan, S., Bhaskaran, R. and Shanmugam, N. 1986. Preliminary studies to develop techniques for early detection of Thanjavur wilt in coconut. *Indian Cocon. J.* 17(3): 3-6.
- Nishitha Naik, V. 1990. Variability and characteristics of different isolates of *Thielaviopsis paradoxa* pathogen of coconut stem bleeding disease. M. Phil. Dissertation, Mangalore University. pp. 94.
- Nowell, W. 1925. Coconut bud rot in Trinidad. *Trop. Agriculturist* 64: 257-277.
- De Nuce, M. de Lamothe, 1988. Proposed *Phytophthora* IRHO-PCA Res. Project. pp. 9.
- Obazee, E.N. and Ikoun, T. 1985. The occurrence of a leaf spot disease of coconut palm caused by *Pestalotia palmarum* Cooke in Nigeria. *Fitopathol. Bras.* 10: 167-169.
- Ohler, J.G. 1984. Coconut: Tree of Life. FAO, Rome. pp. 446.
- Patil, S.D. and Kelkar, P.V. 1975. Endosperm rot of palm fruits. *Indian J. Mycol. Pl. Path.* 5: 61.
- Peiris, J.W.L. 1962. Bud rot of coconuts. *Ceylon Cocon. Pbs. Rev.* 3: 37-40.
- Peries, O.S., Liyanage, A. de S., Mahindapala, R. and Subasinghe, S.M.P. 1975. The incidence of *Ganoderma* root and bole rot of coconut in Sri Lanka. *Ceylon Cocon. Quart.* 26: 99-103.
- Petch, T. 1906. Diseases of the coconut palm. *Trop. Agriculturist* 27: 489-491.
- Potty, N.N. and Radhakrishnan, T.C. 1978. Stem bleeding disease of coconut — nutritional relationship. In: *Proc. Placrosym I.* Indian Society for Plantation Crops, Kasaragod, Kerala. pp. 347-350.
- Pusposindjojo, N. and Christensen, C.M. 1977. Fungus flora of coconuts. *Turialba* 27: 255-258.
- Quillec, G. and Renard, J.L. 1975. Helminthosporiose disease of coconut. Preliminary studies. *Oleagineux* 30: 209-213.
- Quillec, G. and Renard, J.L. 1984. *Phytophthora* rot of coconut. *Oleagineux* 39: 143-147.
- Quillec, G., Renard, J.L. and Ghesquiere, H. 1984. *Phytophthora heveae* of coconut palm: its role in heart rot and nut fall. *Oleagineux* 39(10): 477-485.
- Radha, K. 1961. Leaf rot disease of coconut. In: *Proc. First Session FAO Tech. Wkg. Pty. on Coconut Prod. Prot. and Processing, Trivandrum.* pp. 30-36.
- Radha, K. 1965. Effect of foliar applications of micronutrients on leaf rot and yield of coconut. *Sci. Cult.* 31: 37.
- Radha, K. and Joseph, T. 1974. Investigations on the bud rot disease (*Phytophthora palmivora*) of coconut. Final Report PL 480 Scheme, pp. 32.
- Radha, K. and Joseph, T. 1983. Bud rot diseases of coconut. A reappraisal of associated factors. In: *Coconut Research and Development.* pp. 333-340. N.M. Nayar (Ed.). Wiley Eastern Ltd., New Delhi.

- Radha, K. and Lal, S.B. 1968. Some observations on the occurrence of leaf rot disease of coconut and the associated factors. Paper, 3rd Session FAO Tech. Wkg. Pty. on Coconut Prod. Prot. and Processing, Jogjakarta, Indonesia.
- Radha, K. and Menon, K.P.V. 1954. Studies on the root (wilt) disease of coconut palm. *Indian Cocon. J.* 7: 99-106.
- Radha, K., Sahasranaman, K.N. and Menon, K.P.V. 1962. A note on the yield of coconut in relation to rainfall and leaf rot and root (wilt) disease. *Indian Cocon. J.* 16: 3-11.
- Radha, K., Sukumaran, C.K. and Prasannakumari, T.U. 1961. Studies on the leaf rot disease of coconut. Fungal infection in relation to environmental conditions. *Indian Cocon. J.* 15: 1-11.
- Radhakrishnan, T.C. 1987. Symptom expression in stem bleeding disease of coconut in relation to season. *Indian Phytopath.* 40: 100-102.
- Radhakrishnan, T.C. 1990. Control of stem bleeding disease of coconut. *Indian Cocon. J.* 20(9): 13-14.
- Ramapandu, S., Satyanarayana, Y., Rajamannar, M. and Chiranjeevi, V. 1980. Seasonal variation in the manifestation of *Ganoderma* wilt disease of coconut. *Indian J. Mycol. Pl. Path.* 10(2): 58.
- Rao, A.P. and Subramanyam, K. 1975. A new record of *Alternaria* on coconut leaf (*A. alternata*). *Indian Phytopath.* 28: 404-407.
- Rao, K.S.N., Sreekantiah, K.R. and Rao, T.N.R. 1971. Post-harvest infection of coconut kernel by *Botryodiplodia theobromae* and a note on the hydrolytic enzymes secreted by the fungus. *Indian Phytopath.* 24: 815-819.
- Rao, S.C. 1988a. Leaf spot disease of coconut incited by *Bipolaris incurvata* (Bern.) Alc. *Curr. Sci.* 57: 674-675.
- Rao, S.C. 1988b. Reaction of coconut cultivars of Andamans to grey leaf spot infection. *Indian Cocon. J.* 19(3): 7.
- Rao, S.C. and Renukumar, 1989. Leaf spot incited by *Cercospora apii* Fr. group on *Cocos nucifera*. *FAO Pl. Prot. Bull.* 37: 133.
- Reddy, M.K. and Ananthanarayan, T.V. 1984. Detection of *Ganoderma lucidum* in betel nut by the fluorescent antibody technique. *Trans. Brit. Mycol. Soc.* 82: 559-561.
- Reinking, O.A. 1919. *Phytophthora faberi* Maubl. The cause of coconut bud rot in the Philippines. *Philipp. J. Sci.* 14: 131-151.
- Rethinam, P. 1984. Thanjavur wilt disease of coconut in Tamil Nadu. *Indian Cocon. J.* 15(2): 3-11.
- Rillo, E.P. and Paloma, M.B.F. 1989. Reaction of some coconut cultivars and hybrids to *Phytophthora* disease. *Philipp. J. Cocon. Studies* 14(1): 2-6.
- Salgado, M.L.M. 1942. Note on physiological stem bleeding of mature coconut palm. *Trop. Agriculturist* 98: 31-35.
- Samraj, J., Paily, P.V. and Cheeran, A. 1966. Observation on the aerial application of an oil based fungicide against the leaf rot disease of the coconut palm. *Agric. Res. J. Kerala* 4: 67-70.
- Sanal Kumar, R. 1990. *In vitro* interaction of *Thielaviopsis paradoxa* with mycoflora of coconut root zone. M. Phil. Thesis in Bioscience (Plant Protection), Mangalore University. pp. 94.
- Sanchez Potes, A. 1966. Diseases of cotton, coconut and oil palm in Colombia. *Acta Agron. Palmira* 16: 1-13.
- Schut, B. 1975. A possible phytotoxic effect of copper on dwarf coconut palms. *Surinaamse Landbouw* 23: 26-30.
- Sharma, R.B., Roy, A.N. and Sharma, M.P. 1985. A new disease of coconut kernel. *Curr. Sci.* 54: 199-200.
- Shaw, F.J. and Sundararaman, S. 1914. The bud rot of coconut palms in Malabar. *Annals Mycologia* 12: 251-262.
- Sitepu, D. and Darwis, S.N. 1989. Current knowledge, management techniques and areas of future work for major coconut diseases in Indonesia. pp. 201-219. In: *Coconut Production and Productivity*: Proc. 26th Cocotech Meeting (ed.) Sumith de Silva, APCC, pp. 377.
- Sivanesan, A. 1979. *Trabutia cocoicola* sp. nov. on coconut from the Seychelles. *Trans. Brit. Mycol. Soc.* 73: 173-176.
- Sivanesan, A., Shaw, D.E. and Brown, J.S. 1976. *Leiosphaerella longispora* sp. nov. on coconut petiole in Papua New Guinea. *Trans. Br. Mycol. Soc.* 67: 529-532.
- Steer, J. and Coates-Beckford, P.L. 1990. Role of *Phytophthora katusae*, *P. palmivora*, *Thielaviopsis paradoxa* and *Enterobacter* in bud rot disease of coconuts in Jamaica. *Oleagineux* 45(12): 539-545.

- Stevens, F.L. 1932. Two fungus invasions following coconut leaf miner *Promecothea cumingii* Baly. *Philipp. Agriculturist* 21: 80-82.
- Stockdale, F.A. 1907. Coconut palm disease in Trinidad. *Bull. Dept. Agr. Jamaica* 5: 111-139.
- Sulladmath, V.V. and Ponnappa, K.M. 1978. Petiole disease of coconut palm caused by *Anthostomella fusispora* Broth and Shaw. *J. Plantr. Crops* 6: 65-66.
- Sulladmath, V.V. and Shantappa, P.B. 1979. Nut fall in coconut associated with *Botryosphaeria rhodina* (Berk. and Curt.) V. Arx. *Curr. Res.* 8: 13.
- Sulladmath, V.V., Shantappa, P.B. and Rajanna, H.P. 1980. Aetiology of stem bleeding disease of coconut in semi-dry tract of Karnataka. *Curr. Res.* 9(5): 73-75.
- Sundararaman, S. and Ramakrishnan, T.S. 1924. The 'Mahali' disease of coconuts in Malabar. *Memoirs of Dept. Agr. India Bot. Ser.* 13: 87-97.
- Susamma, P. and Menon, M.R. 1983. Storage studies of copra. In: *Proc. National Seminar on Management of Diseases of Oilseed Crops*, TNAU, Madurai, India. p. 107.
- Susamma, P., Menon, M.R. and Thomas, E.J. 1980. Influence of moisture and weather conditions on microbial population in copra. *J. Plantr. Crops* 8: 36-39.
- Tey, C.C. and Chan, E. 1980. Disease of coconut palms in Peninsular Malaysia. In: *Proc. of the International Conf. on Cocoa and Coconuts, Kuala Lumpur, Malaysia* 21-24 June, 1978. MARDI, pp. 692-707.
- Thomas, K.M., Ramakrishnan, T.S., Soumini, C.K. and Balakrishnan, M.S. 1947. Studies on the genus *Phytophthora*. 1. Oospore formation and taxonomy of *Phytophthora palmivora* Butl. In: *Proc. Indian Acad. Sci.* 26(B): 147-163.
- Thompson, A. 1933. Annual Report for 1931 of Division of Mycology, Dept. of Agriculture, *Strait Settlement and Federated Malay States Bull.* 12: 48-52.
- Tucker, C.M. 1926. *Phytophthora* bud rot of coconut palms in Puerto Rico. *J. Agric. Res.* 32: 471-498.
- Turner, G.J. 1965. Plant Pathology, Report of Research Branch, Dept. of Agriculture, Sarawak, 1964, 70-78.
- Usman, N.M. 1988. Studies on stem bleeding disease of coconut. 1. Survival of *Thielaviopsis paradoxa* in soil. 2. *In vitro* interaction of *T. paradoxa* with antagonistic fungi. M. Phil. Thesis, Mangalore Univ. pp. 74.
- Varghese, M.K. 1934. *Diseases of the Coconut Palm*. Dept. of Agriculture and Fisheries, Travancore. pp. 105.
- Venkataraman, S.V. 1936. The biology of *Ganoderma lucidum* on arecanut and coconut palms. *Phytopathology* 26: 153-175.
- Vijayan, K.M. and Natarajan, S. 1972. Some observations on the coconut wilt disease of Tamil Nadu. *Cocon. Bull.* 2(12): 2-4.
- Vijayaraghavan, H., Ramadoss, N. and Bhaskaran, R. 1987. Approaches for early detection of Thanjavur wilt disease of coconut. pp. 16-17. (Abstract) *Intern. Symp. on Ganoderma Wilt Diseases on Palms and Other Perennial Crops*. 6-8 Jan. 1987, Thanjavur, India. pp. 28.
- Van Uexkull, H.R. 1985. Chlorine in the nutrition of palm trees. *Oleagineux* 40: 67-74.
- Ward, F.S. 1937. Insects, fungi and bacteria associated with copra in Malaysia. 2. Deterioration of copra caused by bacteria and moulds. pp. 108, Dept. of Agr., Straits Settlements and Federated Malay States.

DISCUSSION

P.A.C.R. Perera: What were the fungicides used in the root feeding technique and indicate whether the roots used were cut roots or uncut roots?

K.K.N. Nambiar: Calixin and Bavistin were used separately and individually. Young roots, both uncut roots with root cap intact and cut roots can be used.

M.R. Sharma: Are there any residues when fungicides are used?

K.K.N. Nambiar: No residue of Calixin or Bavistin is found in nut water of treated coconut palms.